SOME ASPECTS OF THE PRESETTLEMENT VEGETATION OF THE PICEANCE BASIN, COLORADO

William L. Baker[1]

Abstract.— Eight plant associations, not previously described in Colorado, and representative of part of the presettlement vegetation spectrum in the oil shale region of northwestern Colorado, are described and illustrated, based on an inventory of relatively undisturbed vegetation remnants.

The Piceance Basin is underlain by oil shale estimated to contain 1.2 trillion barrels of oil (Murray and Haun 1974). Interest in the potential development of this resource has resulted in extensive study of the current vegetation of the basin. Most of this research consists of reports (Ferchau 1974, Keammerer 1977, Keammerer and Stoecker 1975) and theses (Tiedeman 1978, Vories 1974), though two published studies are available (Tiedeman and Terwilliger 1978, Ward et al. 1974). A few regional studies (James and Marr 1966, Marr and Buckner 1974, Marr et al. 1973) contain some quantitative data or general description of the Piceance Basin.

Some additional reports pertain to the Roan and Parachute Creek areas south of the Piceance Basin (Ferchau 1973, Keammerer 1974, Keammerer and Keammerer 1980, Keammerer and Peterson 1981, Thorne Ecological Institute 1973). Graham (1937) provides a general overview of major vegetation types in the Uinta Basin, including this general area of Colorado.

None of these studies characterizes potential vegetation, presettlement vegetation, or habitat types (Daubenmire 1952), concentrating instead on existing vegetation, much of which has been altered by over 100 years of domestic livestock grazing and agriculture. Knowledge of both potential and existing vegetation is essential if land managers are to be able to effectively rehabilitate disturbed lands.

The goal of this paper is to discuss and present data on eight plant associations representative of presettlement vegetation in the Piceance Basin, based on a study of relatively undisturbed remnants. A qualitative overview of the vegetation in this area, and the impacts of grazing on this vegetation are discussed in Baker (1982). This information was gathered as part of a general botanical inventory of the Piceance Basin (Peterson and Baker 1982).

Study Area

The Piceance Basin is located in Rio Blanco and Garfield counties in northwestern Colorado. It is an approximately 2850 km^2 (1100 mi^2) saucer-shaped basin bounded on the south by the Roan Plateau, on the west by the Douglas Creek drainage, on the north by the White River, and on the east by the Grand Hogback. The Piceance Basin is often considered to be a part of the eastern Uinta Basin.

The entire study area is underlain by the Eocene Green River Formation, a kerogen-bearing marlstone (Donnell 1961), which outcrops as large cliff exposures around the margin of the basin, and also occurs scattered throughout the central part of the basin as narrow bands, or tongues, in a Uinta Formation matrix. The Eocene Uinta Formation, predominately a brown sandstone, is the primary exposed surface rock over much of the central part of the basin.

Climatic data are available from Craig, Colorado (Gale Research Co. 1980), 75 km northeast of the study area, at about the same elevation as the central part of the basin. Mean annual precipitation there is 338 mm,

[1]Colorado Natural Heritage Inventory, 1550 Lincoln Street, Suite 110, Denver, Colorado 80203.

distributed fairly evenly throughout the year, with a slight peak from afternoon convective thundershowers in August. Mean January temperature is –7.7 C, with mean July temperature 19.4 C.

The study area is vegetationally similar to other parts of the Uinta Basin. *Atriplex confertifolia* stands occur at the lowest elevations on slopes, with *Artemisia tridentata* stands, sometimes mixed with *Sarcobatus vermiculatus*, occupying draws and creek bottoms. *Juniperus osteosperma–Pinus edulis* woodlands alternate with *Artemisia tridentata* openings on uplands below 2300 m, with *Agropyron spicatum* var. *inerme* grasslands formerly occupying flat ridges and uplands, and southerly-facing slopes. Above 2300 m, these grasslands are interrupted on slopes by a mixed shrub vegetation dominated by *Quercus gambelii*, *Amelanchier utahensis*, *Prunus virginiana*, *Rosa woodsii*, *Cercocarpus montanus*, and *Symphoricarpos oreophilus*, and occasional patches of *Pseudotsuga menziesii* or *Populus tremuloides* forests on the most protected northerly-facing slopes. The study area has been extensively grazed by cattle and sheep since the late 1800s. Many of the valley bottoms have been converted to agriculture. Mining of oil shale is currently limited to two 5000-acre Federal prototype lease tracts.

METHODS

From May to August 1982, a reconnaissance survey was conducted to locate relatively ungrazed and unlogged vegetation remnants in the study area. Every section of approximately 1100 sections in the study area was searched. Methods of locating such remnants are similar to methods used by Daubenmire (1970). Remnant areas were recognized by the following general features: (1) absence of obvious physical signs of grazing, such as cattle and sheep trails and terraced slopes, bedding areas, excessive amounts of trampled and broken shrub stems, compacted soils, scat, and logging or woodcutting signs, such as stumps, access roads, cutting debris, etc.; (2) absence or low coverage of exotic plant species (e.g., *Bromus tectorum*, *Poa pratensis*, *Chorispora tenella*); (3) low coverage of plant species known to increase when domestic grazing occurs (e.g., *Chrysothamnus* spp., *Gutierrezia sarothrae*, *Artemisia frigida*); (4) presence of at least remnants of a soil cryptogam layer on relatively flat sandy to silty soils. On rocky sites, slopes, or talus, presence of large crustose lichens on exposed rock surfaces is suggestive of lack of recent heavy use, because rocks turned or dislodged by cattle and sheep hoof action cannot maintain large lichen growths; (5) presence of healthy, large native plants, generally abundant grass cover, with individual grass plants having many flower stalks, standing litter, and live centers; (6) general absence of plant pedestaling, excessive rilling and gullying, and other signs of excessive or accelerated erosion. Some additional features are specific to particular associations. Generally, a combination of these factors made identification of remnants relatively simple. Remnants generally occurred on steep or inaccessible slopes far from water, or in areas excluded from grazing by accidents of fencing. Observations on effects of grazing on each association are based on a qualitative comparison of several sites and fenceline contrasts.

Remnants located were sampled quantitatively using a .1 hectare (20 × 50 m) plot method widely used in gradient analysis (e.g., Peet 1981). Shrub and herb percent canopy cover were sampled along the center line of the plot using 25 consecutive .5 × 2 m quadrats. Plots were located in areas of visually homogenous vegetation. Tree size class structure was sampled by tallying stem within the plot in 2-inch size classes, with diameter measured at breast height, or below the major point of branching (on *Juniperus* and *Pinus*).

This study concentrates on eight plant associations sampled and characterized based on 27 stands. Classification follows the methods of Daubenmire (1970). The entire spectrum of presettlement vegetation in the Piceance Basin could not be sampled quantitatively, partly because of time constraints, and partly because sufficient remnants could not be located that were free of disturbance effects, to characterize the original composition of all the associations. A preliminary qualitative classification of the original vegetation of the basin, based on

inference and reconnaissance data, and comparison with literature from adjoining areas is in Baker (1982).

Nomenclature follows Kartesz and Kartesz (1980). Voucher specimens are deposited at the Colorado State University Herbarium (CS). Soil types cited with each association were not sampled in each plot, but are based on recent soil maps (Tripp et al. 1982).

Results and Discussion

Table 1 summarizes shrub and herb percent cover. Table 2 summarizes tree size class data. Each of the associations is illustrated in Figure 1 and discussed below.

1. *Juniperus osteosperma–Pinus edulis/Agropyron spicatum* var. *inerme*

This association occupies gently sloping ridge tops and crests of low hills and mesas, often southerly-facing, between 1700 and 2150 m in elevation. It most often occurs on Uinta Formation sandstone, but may also occur on Green River Formation marlstone. Sampled stands occur exclusively on the Rentsac soil series, a Lithic Ustic Torriorthent, common in the basin (Tripp et al. 1982).

The association has a savannalike appearance (Figure 1a), with widely spaced trees in a dense grass matrix and few shrubs present. *Oryzopsis hymenoides* may codominate in some stands, but is most commonly a minor species or is absent entirely. A moderately developed soil cryptogam layer occurs in excellent condition stands.

The association is at the lower, drier elevational end of the pinyon-juniper zone in this area. *Juniperus* appears to be slightly better adapted to these sites than *Pinus*, having more stems on most sites (Table 2). A few sites may lack *Pinus* entirely. Both species generally have good reproduction and commonly have a few large, old stems on most sites.

The association degrades on relatively flat sites, under heavy domestic grazing, to a similar community with *Haplopappus acaulis* dominant in the understory. This community has been described by Vories (1974, Association 14). On more sloping sites *Artemisia tridentata*, *Gutierrezia sarothrae*, *Chrysothamnus* spp., and *Bromus tectorum* become dominants.

This association has not been reported from other parts of Colorado, but Shute and West (no date) mention a similar association from the Uinta Basin near Price, Utah, where *Agropyron spicatum* var. *inerme* dominates the understory of pinyon-juniper woodlands on "level mesa tops, deep wind-deposited (or sandy if shallow over sandstone) soils . . ." (p. 26). Though compositional data are not provided, this is a similar environmental position and similar dominants. Data in Isaacson (1967, Table 5, plots 147–149, 192) also appear to represent this association. These data were collected at unspecified localities in the Uinta Basin of Colorado and Utah. It appears likely that this association occurs in scattered localities across the Uinta Basin. This association is related to the *Juniperus osteosperma/Agropyron spicatum* association common in western Wyoming (Wight and Fisser 1968), which also occurs in Moffat County, Colorado. That association occurs north of the range limit of *Pinus edulis*. The awned variety (var. *spicatum*) of *Agropyron spicatum* is rare in the Piceance Basin, and never occurs mixed with *A. spicatum* var. *inerme*.

2. *Juniperus osteosperma–Pinus edulis/Amelanchier utahensis–Cercocarpus montanus* marlstone barren

This association occurs on generally southerly-facing slopes of white marlstone of the Green River Formation, from 1975 to 2450 m in elevation. These sites have soils mapped as a complex of Torriorthents and Rock Outcrops (Tripp et al. 1982).

A well-developed tree and shrub layer are always present, but almost no herbaceous layer occurs. The association has conspicuous expanses of open, bare, exposed, partly decomposed white marlstone (Fig. 1b), alternating with clumps of *Amelanchier and Cercocarpus*. *Ephedra viridis* is often present.

Pinus edulis is often more abundant than *Juniperus osteosperma* on these sites, but old stems of both species commonly occur. *Pinus edulis* generally has more seedlings and saplings in this association than in any other association in the basin (Table 2).

TABLE 1. Percent cover and constancy of shrubs and herbs. Plant association numbers correspond to those in the text. 1 = *Juniperus osteosperma–Pinus edulis/Agropyron spicatum* var. *inerme*, 2 = *Juniperus osteosperma–Pinus edulis/Amelanchier utahensis–Cercocarpus montanus* marlstone barren, 3 = *Pinus edulis/Amelanchier utahensis–Arctostaphylos patula–Cercocarpus montanus/Carex pityophila*, 4 = *Pseudotsuga menziesii/Amelanchier utahensis–Quercus gambelii–Symphoricarpos oreophilus/Carex geyeri–Poa fendleriana*, 5 = *Artemisia tridentata* ssp. *wyomingensis–Symphoricarpos oreophilus/Elymus cinereus*, 6 = *Atriplex confertifolia/Agropyron spicatum* var. *inerme–Oryzopsis hymenoides*, 7 = *Agropyron spicatum* var. *inerme* Great Basin grassland, 8 = *Agropyron spicatum* var. *inerme–Oryzopsis hymenoides* Great Basin grassland. Table entries are percent canopy cover, followed by percent constancy, tr = trace quantities (less than .5 percent average cover); 100 percent is abbreviated to 99.9 percent.

Plant association number	1	2	3	4	5	6	7	8
Number of stands	4	3	3	3	3	4	4	3
SHRUBS								
Artemisia tridentata								
ssp. *wyomingensis*	.9 99.9	tr 33.3		tr 99.9	19.1 99.9	.8 99.9	tr 50.0	tr 99.9
Atriplex confertifolia	tr 25.0					5.4 99.9	tr 25.0	
Chrysothamnus viscidiflorus	tr 75.0	tr 33.3	tr 66.6	tr 33.3	1.9 99.9	tr 75.0	1.0 50.0	1.7 66.6
Chrysothamnus nauseosus	tr 75.0				3.0 66.6			tr 66.6
Symphoricarpos oreophilus	tr 99.9	tr 66.6	tr 66.6	12.4 99.9	28.6 99.9	tr 25.0	tr 25.0	
Tetradymia canescens	tr 50.0		tr 33.3				tr 75.0	
Ceratoides lanata	tr 25.0						tr 50.0	
Amelanchier utahensis	tr 25.0	11.5 99.9	11.7 99.9	3.7 66.6	tr 99.9		tr 50.0	
Cercocarpus montanus	tr 25.0	15.1 99.9	16.9 99.9	tr 33.3				tr 33.3
Quercus gambelii				13.6 99.9				
Ephedra viridis		1.3 33.3						
Purshia tridentata	tr 50.0	tr 33.3	tr 33.3	tr 33.3				
Mahonia repens		tr 66.6	tr 66.6	tr 99.9				
Gutierrezia sarothrae	tr 99.9			tr 33.3		tr 50.0	tr 50.0	
Chrysothamnus parryi						tr 25.0		
Arctostaphylos patula			24.8	99.9				
Pachistima myrsinites			tr 33.3	.6 66.6				
Artemisia frigida	tr 50.0					.9 99.9	tr 75.0	.8 99.9
Rosa woodsii				tr 33.3	.8 33.3			
Ribes inerme				tr 66.6				
Ceanothus martinii			tr 33.3					
Ribes cereum	tr 25.0							
GRAMINOIDS								
Carex pityophila	.6 99.9	tr 66.6	4.2 99.9	.8 99.9				
Carex geyeri				7.8 99.9	1.9 66.6			
Carex sp.					tr 66.6			
Bromus tectorum	tr 75.0				tr 33.3	tr 25.0		tr 33.3
Stipa comata	1.4 75.0				1.6 33.3	tr 25.0	.6 25.0	tr 66.6
Poa sandbergii	tr 75.0						tr 25.0	
Poa fendleriana	tr 75.0			3.2 99.9	tr 33.3			
Agropyron spicatum								
var. *inerme*	16.0 99.9	tr 33.3	tr 66.6	tr 33.3		13.8 99.9	22.1 99.9	11.8 99.9
Oryzopsis hymenoides	5.1 99.9	tr 33.3	tr 66.6	tr 99.9	tr 66.6	5.6 99.9	1.2 99.9	9.8 99.9
Koeleria cristata	1.8 99.9			tr 99.9	tr 33.3	tr 25.0	2.4 75.0	
Oryzopsis micrantha				1.0 66.6				
Bromus ciliatus				tr 33.3	1.5 99.9			
Elymus cinereus				tr 33.3	20.5 99.9			tr 33.3
Stipa columbiana					1.8 99.9			
Poa pratensis					1.9 66.6			
Agropyron smithii				tr 33.3	.5 99.9		tr 25.0	
Agropyron trachycaulum				tr 66.6	5.6 99.9			
Poa interior					.8 99.9			
Bromus carinatus					tr 66.6			
Stipa lettermanii				tr 33.3	tr 66.6			
Poa nevadensis					tr 33.3			
Sitanion hystrix				tr 66.6		tr 25.0		
FORBS								
Eriogonum umbellatum	tr 50.0		tr 33.3	tr 66.6	tr 33.3			
Machaeranthera grindelioides	.8 99.9	tr 66.6	tr 99.9			tr 50.0		

Table 1 continued.

Plant association number	1	2	3	4	5	6	7	8
Number of stands	4	3	3	3	3	4	4	3
Opuntia polyacantha	tr 50.0							
Chamaesyce fendleri	tr 50.0							
Phlox hoodii	.9 99.9							
Physaria acutifolia	tr 75.0	tr 99.9	tr 66.6			tr 75.0	tr 75.0	tr 66.6
Taraxacum officinale	tr 25.0			tr 33.3	1.5 99.9			
Galium coloradense	.6 99.9					tr 25.0	tr 25.0	1.1 33.3
Haplopappus acaulis	.7 75.0							
Cryptantha sericea	tr 99.9	tr 33.3	tr 33.3	tr 66.6		tr 75.0	.5 75.0	tr 33.3
Commandra umbellata	tr 50.0			tr 33.3			tr 25.0	
Astragalus chamaeleuce	tr 50.0					tr 50.0	tr 50.0	tr 33.3
Hymenopappus filifolius	.5 25.0		tr 33.3			tr 25.0	tr 25.0	
Senecio multilobatus	tr 99.9		tr 66.6	tr 33.3			tr 25.0	
Arabis spp.	tr 25.0	tr 33.3		tr 33.3			tr 25.0	tr 33.3
Eriogonum lonchophyllum	tr 75.0					1.4 99.9	1.5 99.9	1.4 99.9
Cirsium spp.	tr 75.0					tr 50.0	1.4 75.0	.9 66.6
Stephanomeria tenuifolia	tr 50.0					tr 25.0	tr 50.0	tr 66.6
Leptodactylon pungens	tr 33.3					tr 25.0	tr 25.0	tr 33.3
Astragalus convallarius	tr,75.0			tr 33.3	tr 33.3	tr 25.0	tr 25.0	tr 33.3
Senecio werneriifolius	tr 50.0							
Arabis lignifera	tr 75.0	tr 33.3						
Ipomopsis aggregata	tr 50.0			tr 33.3			tr 25.0	tr 33.3
Penstemon osterhoutii	tr 50.0					tr 25.0	tr 25.0	
Eriogonum alatum	tr 25.0						tr 25.0	
Phlox austromontana		.6 99.9	2.1 66.6					tr 66.6
Streptanthus cordatus	tr 50.0	tr 66.6	tr 66.6					
Draba sp.		tr 33.3						
Cryptantha flavoculata		tr 99.9	tr 33.3				tr 25.0	
Descurainea sp.		tr 33.3					tr 25.0	
Penstemon caespitosus	tr 25.0	tr 66.6	tr 99.9	tr 33.3			tr 25.0	
Lithospermum ruderale			tr 33.3		.5 99.9			
Frasera speciosa			tr 33.3	tr 33.3				
Achillea millefolium var. *lanulosa*			tr 66.6	tr 66.6	1.5 99.9			tr 33.3
Astragalus miser			.8 33.3	1.4 66.6	tr 33.3			
Caulanthus crassicaulis	tr 25.0	tr 33.3	tr 66.6			tr 25.0		
Galium boreale				tr 66.6	.9 99.9	tr 25.0		
Erigeron speciosus				1.8 99.9	tr 99.9			
Clematis occidentalis var. *dissecta*				tr 33.3				
Penstemon strictus				tr 33.3	tr 66.6			
Balsamorhiza sagittata		tr 66.6	tr 66.6	tr 66.6	tr 66.6			
Castilleja linariifolia				tr 66.6	tr 99.9			
Crepis occidentalis				tr 33.3	tr 66.6			
Calochortus gunnisonii				tr 33.3	tr 99.9			
Cirsium calcareum		tr 33.3	tr 33.3	tr 66.6			tr 25.0	
Artemisia ludoviciana	tr 25.0			tr 66.6	tr 33.3	tr 50.0	tr 50.0	1.8 99.9
Viguiera multiflora					tr 33.3			
Chenopodium sp.					tr 33.3			tr 66.6
Crepis acuminata					tr 33.3			
Oenothera sp.					1.5 99.9			
Descurainea pinnata					tr 33.3			
Collomia linearis					tr 66.6			
Androsace septentrionalis				tr 33.3	tr 33.3			
Microsteris gracilis ssp. *humilis*					tr 33.3			
Penstemon watsonii				tr 66.6	.5 33.3			
Ligusticum porteri					tr 66.6			
Geranium fremontii					.9 99.9			
Lupinus caudatus					1.1 66.6			
Composite sp.				tr 33.3	tr 66.6			

Table 1 continued.

Plant association number	1	2	3	4	5	6	7	8
Number of stands	4	3	3	3	3	4	4	3
Potentilla gracilis var. *pulcherrima*					tr 33.3			
Tragopogon dubius					tr 99.9			
Astragalus lutosus						tr 25.0	tr 50.0	
Penstemon sp.	tr 25.0					tr 25.0	tr 25.0	tr 33.3
Artemisia dracunculus						tr 75.0	tr 25.0	tr 66.6
Mentzelia humilis						tr 50.0	tr 25.0	.8 99.9
Astragalus kentrophyta	tr 75.0					tr 25.0	1.5 25.0	tr 33.3
Linum lewisii	tr 25.0						.7 75.0	tr 33.3
Euphorbia robusta	tr 50.0		tr 33.3			tr 25.0	tr 50.0	tr 66.6
Phacelia heterophylla				tr 33.3			tr 25.0	tr 33.3
Penstemon fremontii	tr 25.0			tr 33.3		tr 50.0	tr 25.0	
Lesquerella sp.							tr 25.0	
Erysimum asperum				tr 66.6	tr 66.6	tr 25.0	tr 50.0	
Astragalus spatulatus	tr 25.0						tr 25.0	
Hedysarum boreale			tr 33.3				tr 25.0	1.1 33.3
Phlox longifolia							tr 25.0	
Hymenoxys acaulis							tr 25.0	
Chaenactis douglasii							tr 50.0	
Oenothera caespitosa						tr 50.0		tr 66.6

The association has not been reported or named from other areas, though data in Keammerer and Peterson (1981:24) suggest an association very similar to this in composition occurs on the Naval Oil Shale Reserve directly adjoining the southern boundary of this study area. It is likely the association is restricted to Green River Formation exposures in the Piceance Basin/Roan Plateau area of Colorado.

3. *Pinus edulis/Amelanchier utahensis–Arctostaphylos patula–Cercocarpus montanus/Carex pityophila*

This association occurs on flat to gently sloping ridge top exposures of Green River Formation marlstone, from 2100 to 2450 m in elevation. All stands are mapped as occurring on the Rentsac soil series, a Lithic Ustic Torriorthent common in the basin (Tripp et al. 1982).

This association has a very dense shrub layer, and a depauperate herbaceous layer. It is the only association in the basin containing *Arctostaphylos patula* and *Ceanothus martinii*. The association always has very sharp boundaries. One can step across a line onto adjoining Uinta Formation sandstone, where *Arctostaphylos* does not occur, *Juniperus osteosperma* is co-dominant with *Pinus edulis*, and the herbaceous layer is much better developed. *Pinus edulis* is the only tree present on most sites. *Juniperus osteosperma* may have a few stems or seedlings on some sites (Table 2).

The association appears to be very fire susceptible, possibly due to the high shrub density. About half the range of the association in the basin has burned in the 100 years, and is in a postburn stage dominated by the three shrubs dominant in the understory of the mature stage.

This association has not been reported from other areas. It may be restricted to midelevation exposures of Green River Formation in the Piceance Basin.

4. *Pseudotsuga menziesii/Amelanchier utahensis–Quercus gambelii–Symphoricarpos oreophilus/Carex geyeri–Poa fendleriana*

This association typically occurs on the brows of northerly-facing slopes of draws, 1900–2600 m in elevation. It occurs on either Uinta Formation sandstone or Green River Formation marlstone. Slopes generally do not exceed about 30 degrees. Soils are highly variable from stand to stand, ranging from Cryoborolls and Haploborolls to Torriorthents (Tripp et al. 1982).

This association is more open and less protected than the *Pseudotsuga menziesii/Symphoricarpos oreophilus/Carex geyeri–Poa fendleriana* association also found in the basin (Baker 1982) on steeper slopes

and in more mesic locations. The association has a dense shrub layer, with patches of *Carex* often densest under shrubs, and with *Poa* in the openings. *Quercus* seldom reaches tall shrub stature in this association, most commonly occurring as a low, often trailing shrub. *Amelanchier* may be absent from some low elevation stands on the driest sites. *Quercus* may also be absent from an occasional stand.

Pseudotsuga menziesii may be the only tree in some stands. *Juniperus scopulorum* is more commonly present, and may co-dominate on the most open, driest sites. Both trees appear to reproduce well in this association. *J. scopulorum* is excluded from the name because of only moderate constancy.

The association characteristically is criss-crossed with game trails, which result in much bare ground. Grazing of domestic animals generally reduces *Carex* and *Poa* and results in an increase in the exotic *Poa pratensis* and bare ground.

The association has not been described or named previously, but data in Vories (1974, Association 1), Keammerer (1974:23, 1977:43), Marr et al. (1973, plot 43), and Ferchau (1973:23) probably represent the association. The association has not been located outside the Piceance Basin/Roan Plateau area of Colorado.

5. *Artemisia tridentata* ssp. *wyomingensis–Symphoricarpos oreophilus/Elymus cinereus*

This association occurs near the heads of draws on alluvium, from 2200 to 2600 m in elevation. Soils are mapped in several series, all Cryoborolls (Tripp et al. 1982). The association grades downstream into an *Artemisia tridentata* ssp. *tridentata/Elymus cinereus* association. The association typically occupies only the upper 1–2 km and headwaters area of intermittent stream drainages.

The association is characterized by *Artemisia* scattered through a matrix of tall *Elymus* clumps. *Symphoricarpos* often grows under or interwoven with the *Artemisia* stems and is not readily visible (Figure 1e).

Grazing by domestic animals decreases *Elymus cinereus*, which results in an increase in exotic species (e.g., *Poa pratensis*, *Bromus tectorum*), and the density of shrubs.

This association apparently has not been described previously. It has been observed by this author in scattered localities in western Colorado, including the Danforth–Gray Hills area north of Meeker, and in northern Eagle county, always in essentially the same environmental position near the heads of draws at midelevations.

6. *Atriplex confertifolia/Agropyron spicatum* var. *inerme–Oryzopsis hymenoides*

This association occurs on moderately steep to steep talus slopes of Uinta Formation sandstone, or occasionally on tongues of Green River Formation, from 1850 to 2075 m in elevation. It often occurs on southerly-facing slopes, but may also occur on other aspects. These sites have soils mapped as a complex of Torriorthents and Rock Outcrops (Tripp et al. 1982).

The association has a grassland appearance (Figure 1f), but consistently contains 5–6 percent cover of *Atriplex confertifolia*. The association is characteristically sparse, with only 20–25 percent total cover, and much exposed bare soil.

Grazing by domestic animals generally decreases perennial grasses, and results in increases in *Artemisia tridentata*, *Gutierrezia sarothrae*, and bare ground. Only very rarely does *Atriplex confertifolia* become dense under heavy grazing pressure.

This association apparently has not been described previously. Tiedeman and Terwilliger (1978, p. 212) describe a soil-vegetation unit in the Piceance Basin similar to this association, but with the *Agropyron* identified as *A. trachycaulum*. This author has seen only *A. spicatum* var. *inerme* on dry slopes mixed with *Atriplex*, *A. trachycaulum* being found on more sheltered mesic north-facing slopes and in draws with a mixture of *Amelanchier*, *Artemisia*, *Symphoricarpos*, and other shrubs. A related association, *Atriplex confertifolia/Oryzopsis hymenoides* also occurs in the Piceance Basin and in the Roan Plateau area (Baker 1982), where it is very common on more directly south-facing slopes. This latter association also occurs across the northern Great Basin to California.

7. *Agropyron spicatum* var. *inerme* Great Basin grassland.

This association occurs in two settings in the Piceance Basin: (1) from 1950 to 2450 m in elevation on generally south-facing slopes, often on steep talus, on either Uinta Formation sandstone or Green River Formation marlstone, on soils mapped as a complex of Torriorthents and Rock Outcrops (Tripp et al. 1982); (2) from 2450 to 2700 m in elevation on broad ridge tops and plateaus that are often gently south or southwest facing, occurring on either Uinta Formation sandstone or Green River Formation marlstone, on soils mapped as the Starman-Vandamore complex, which is a complex of Lithic and Typic Cryorthents (Tripp et al. 1982).

This association is a rather sparse grassland with 15–30 percent total cover. *Oryzopsis hymenoides*, which co-dominates in association 8, occurs in this type with generally less than 10 percent of the cover of *Agropyron spicatum* var. *inerme*, and is most often absent entirely. Where it does have significant cover in this association, it has low frequency, occurring as occasional small, dense patches.

After observing numerous stands lacking the undisturbed characteristics cited in the methods section, five successional stages were recognized, based on increasing amounts of grazing impact to this association: (1) *Agropyron spicatum* var. *inerme* dominated climax, (2) *Agropyron spicatum* var. *inerme–Koeleria cristata*, (3) *Koeleria cristata* dominated, with occasional small patches of

TABLE 2. Tree diameter size distribution. Tree diameters are in inches measured at breast height (DBH). Seedlings are less than 1 in DBH and less than 1 m tall. Saplings are less than 1 in DBH and greater than 1 m tall. Entries are number of stems per size class. Species codes are JUOS = *Juniperus osteosperma*, JUSC = *Juniperus scopulorum*, PIED = *Pinus edulis*, PSME = *Pseudotsuga menziesii*.

Stand No.	Species code	Seedlings	Saplings				
				1–3	3–5	5–7	7–9
Juniperus osteosperma–Pinus edulis/Agropyron spicatum var. *inerme*							
1	JUOS	0	0	0	1	5	0
	PIED	0	0	0	1	2	2
2	JUOS	2	0	1	2	2	1
	PIED	4	0	1	4	2	0
3	JUOS	2	0	2	3	8	0
	PIED	4	0	1	0	1	1
	JUSC	0	0	2	0	3	0
4	JUOS	11	4	6	4	4	0
	PIED	3	1	2	2	0	1
Juniperus osteosperma–Pinus edulis/Amelanchier utahensis–Cercocarpus montanus marlstone barren							
5	JUOS	4	0	4	2	0	0
	PIED	16	12	10	8	4	10
6	JUOS	0	4	2	5	0	0
	PIED	4	8	9	14	6	5
7	JUOS	0	1	2	0	0	0
	PIED	5	10	15	4	3	3
Pinus edulis/Amelanchier utahensis–Arctostaphylos patula–Cercocarpus montanus/Carex pityophila							
8	PIED	3	1	3	3	1	2
9	JUOS	1	1	0	1	0	1
	PIED	4	0	3	2	2	2
10	JUOS	2	0	0	0	0	0
	PIED	6	6	12	13	3	1
Pseudotsuga menziesii/Amelanchier utahensis–Quercus gambelii–Symphoricarpos oreophilus/Carex geyeri–Poa fendleriana							
11	PSME	23	11	13	11	8	10
12	PSME	18	16	12	2	2	2
	JUSC	18	16	6	6	2	2
13	PSME	10	2	4	0	2	8
	JUSC	14	4	4	12	12	0
	PIED	2	0	0	0	0	0

Agropyron, (4) *Gutierrezia sarothrae–Chrysothamnus* spp.–*Cryptantha sericea* dominated, with patches of *Koeleria*, (5) bare ground. On steep slopes, stages 2 and 3 may not occur, and *Artemisia frigida*, *Machaeranthera grindelioides*, and other weedy species may mix with stage 4 species. Photographs illustrating each of these stages are in Baker (1982). Hanson and Stoddart (1940) discuss reasons *Agropyron spicatum* var. *inerme* is easily damaged by domestic grazing.

Formerly this very likely was one of the most common vegetation types in the Piceance Basin. Now, perhaps 100–200 acres remain in stage 1 or 2, with most of the former range in stage 3. Hanson and Stoddart (1940) indicate that the association has been similarly depleted in northeastern Utah and southeastern Idaho by overgrazing domestic livestock, though they do not describe successional stages.

This association is known to have occurred in the northern Great Basin in the Cache Valley area of northeastern Utah and southeastern Idaho (Hull and Hull 1974, Hanson 1939, Hanson and Stoddart 1940), approximately 400 km northwest of the Piceance Basin, where it has similarly been described as representative of presettlement conditions in that area. The association has not been described in Colorado. Data in Keammerer and Stoecker (1975:13), and in Tiedeman and Terwilliger (1978:200) appear to represent the *Koeleria* successional stage of this associ-

Table 2 continued.

Inches									
9–11	11–13	13–15	15–17	17–19	19–21	21–23	23–25	25–27	27+
2	3	3	0	1	1	1	1	2	1(30 in)
1	1	0	0	0	0	0	0	0	0
2	0	1	2	0	1	0	2	0	1(34 in)
2	1	1	1	1	1	1	0	0	1(36 in)
8	0	0	1	1	0	0	0	1	1(36 in)
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
3	1	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4	2	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
4	0	0	0	2	0	0	0	0	1(40 in)
0	0	2	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
2	0	1	1	0	1	0	0	0	0
3	0	1	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0
0	1	1	0	0	0	0	2	0	0
0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0
4	5	5	3	1	1	0	0	0	0
2	2	2	2	0	0	0	0	0	0
0	0	2	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
0	4	2	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

ation. These latter authors suggest that, if undisturbed, this type "would reach a stable plant community dominated by needle and thread" (p. 201). We could not locate any remnant areas dominated by *Stipa comata*. *Stipa comata* is commonly a minor component of the higher elevation version of climax *Agropyron spicatum* var. *inerme* grasslands. Where it occurs most commonly, there is always abundant evidence of domestic livestock use, suggesting it may increase temporarily at the expense of the more palatible *A. spicatum* var. *inerme*, and then also decline as impact increases. Data in Vories (1974, Association 3) appear to represent stage 4 of the successional series.

This association is undoubtedly related to the *Agropyron spicatum* associations typical of the Palouse region in the Columbia River Basin of Washington, Idaho, and northern Utah and Nevada, which are represented in the northern Rocky Mountains as montane grasslands, and also occur in central and northern Colorado. Typical *A. spicatum* var. *spicatum*, with long divaricate awns, is rare in the Piceance Basin and never forms grasslands or mixes with *A. spicatum* var. *inerme*. This appears to be the case in northeastern Utah also, where grasslands of the two varieties do occur, but generally are geographically separated (Hull and Hull 1974). Passey and Hugie's (1963) data suggest that *A. spicatum* var. *inerme* grasslands may be limited to the northern Great Basin, not extending into the typical Palouse region, where *A. spicatum* var. *spicatum* dominates.

8. *Agropyron spicatum* var. *inerme–Oryzopsis hymenoides* Great Basin grassland

This association occurs on southerly-facing steep talus slopes of Uinta Formation sandstone, from 1975 to 2200 m in elevation. Soils are mapped as a complex of Torriorthents and Rock Outcrops (Tripp et al. 1982).

This association is also a sparse grassland, with 15–25 percent total cover. *Oryzopsis hymenoides* has half or more of the cover of *Agropyron spicatum* var. *inerme*, and high frequency.

Grazing by domestic animals decreases perennial grasses and results in an increase in *Artemisia frigida*, *Artemisia tridentata*, and *Chrysothamnus* spp., along with the exotic *Bromus tectorum*. This association does not follow the same successional sequence as occurs with association 7.

This association apparently has not been described previously. Vories (1974, Association 25) describes a community that may represent a poor condition example of this association, but the species of *Agropyron* is not identified. Ward et al. (1974, Type II-E) mention this combination of co-dominants but give no additional details. Ferchau (1974, p. 2) mentions a "Wheatgrass-Ricegrass" type that may represent this association, but the species of *Agropyron* is not identified. This association is apparently restricted to the Piceance Basin/Roan Plateau area of Colorado.

Current data, from this study and from Colorado Natural Heritage Inventory files, suggest associations 2, 3, 4, 6, and 8 are restricted to the Piceance Basin/Roan Plateau area of Colorado, though additional information is needed from similar exposures of Green River Formation in northeastern Utah. Associations 1, 5, and 7 are more wide ranging, occurring in scattered localities in northern Utah and northwestern Colorado. Baker (1982) lists an additional three associations, not quantitatively sampled, that are apparently restricted to the Piceance Basin/Roan Plateau area of Colorado. With the exception of association 4, restricted associations are either found on dry southerly-facing slopes and ridge tops (associations 6 and 8), or on rocky exposures of Green River Formation marlstone (association 2 and 3). These more extreme environments in the basin have unique plant associations, in addition to being primary habitat for most of the basin's rare plant taxa (Peterson and Baker 1982). More mesic areas tend to contain wide-ranging associations (e.g., association 5) and lack rare taxa.

Although the concept of climax and the validity of the plant association continue to be subjects of ecological debate, many of the remaining fragments of the presettlement vegetation spectrum are being subjected to inadvertent loss during development and land use. Much of the forest vegetation of the western United States is being or has been studied and classified (cf. Pfister 1982) based

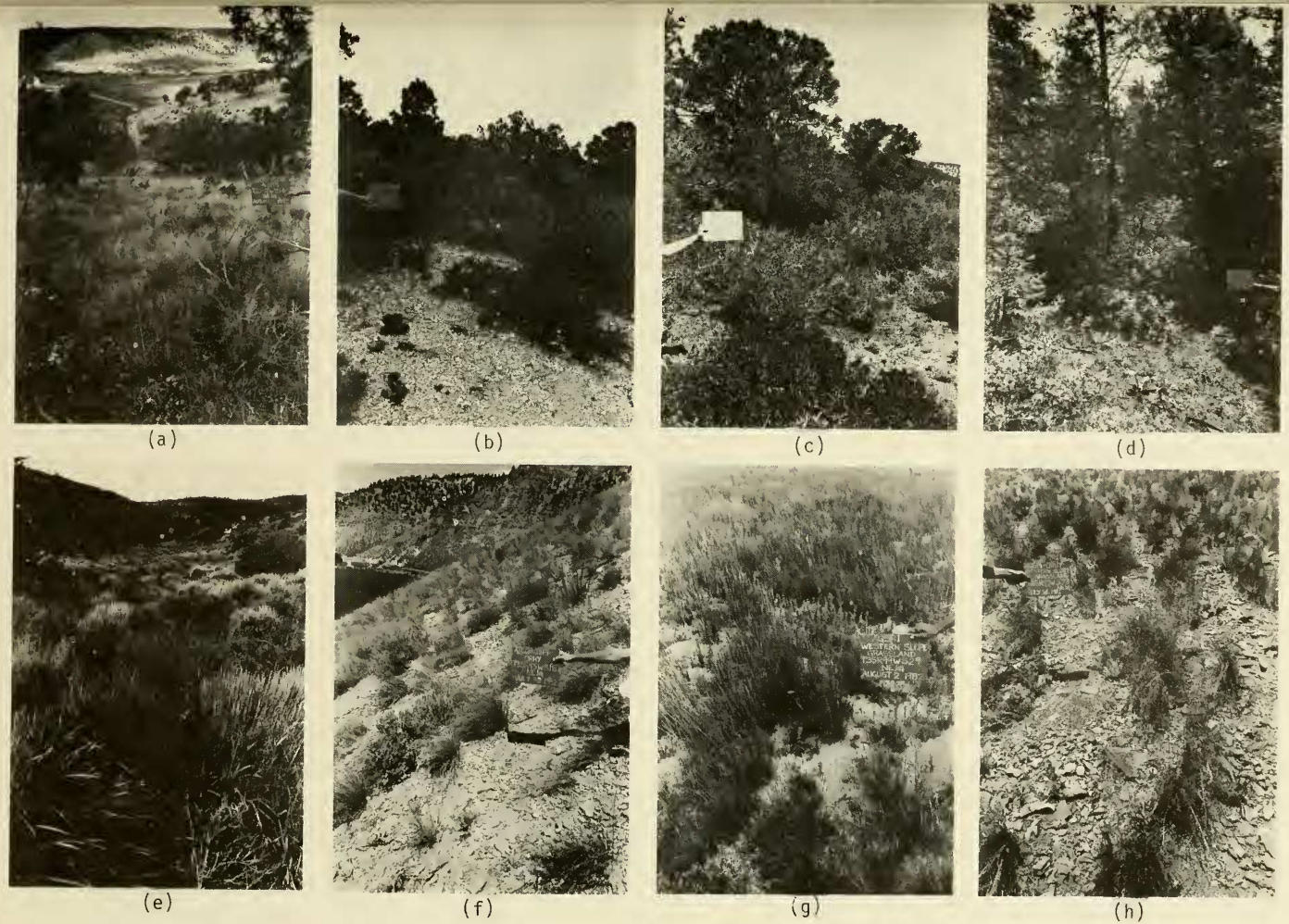

Fig. 1. Eight Piceance Basin plant associations. (a) *Juniperus osteosperma–Pinus edulis/Agropyron spicatum* var. *inerme*, (b) *Juniperus osteosperma–Pinus edulis/Amelanchier utahensis–Cercocarpus montanus* marlstone barren, (c) *Pinus edulis/Amelanchier utahensis–Arctostaphylos patula–Cercocarpus montanus/Carex pityophila*, (d) *Pseudotsuga menziesii/Amelanchier utahensis–Quercus gambelii–Symphoricarpos oreophilus/Carex geyeri–Poa fendleriana*, (e) *Artemisia tridentata* ssp. *wyomingensis–Symphoricarpos oreophilus/Elymus cinereus*, (f) *Atriplex confertifolia/Agropyron spicatum* var. *inerme–Oryzopsis hymenoides*, (g) *Agropyron spicatum* var. *inerme* Great Basin grassland, (h) *Agropyron spicatum* var. *inerme–Oryzopsis hymenoides* Great Basin grassland.

on potential or presettlement plant associations, but a similar effort is needed to catalog and describe plant associations on nonforested and lower elevation sites prior to the loss of the remaining opportunities for study. Although in many areas, such as the Piceance Basin, it may be too late to comprehensively describe and classify the presettlement vegetation spectrum, land managers charged with rehabilitating disturbed lands cannot begin to effectively achieve this goal without as much information as can now be provided on predisturbance conditions.

ACKNOWLEDGMENTS

Part of this study was completed during a contract with the Bureau of Land Management, Craig District Office, Craig, Colorado. I am grateful to Karen Wiley-Eberle, Vernie Armstrong, and Curt Smith of BLM for assistance with logistics. Field crews assisted in locating remnant vegetation areas. I appreciate the efforts of Dr. Dieter Wilken of the Colorado State University Herbarium, who verified all plant specimens. Warren Keammerer, K. Vories, John Marr, Thorne Ecological Institute, EXXON, TOSCO, ARCO, and TRW all supplied access to unpublished data and reports. This study could not have been completed without Tamara Naumann, who volunteered assistance in field sampling. I am also grateful for the support and encouragement of J. Scott Peterson.

LITERATURE CITED

BAKER, W. L. 1982. Natural vegetation of the Piceance Basin, Colorado. *In* J. S. Peterson and W. L. Baker, eds., Inventory of the Piceance Basin, Colorado: threatened and endangered plants, plant associations, and the general flora. Report prepared for the Craig District Office, Bureau of Land Management, by Colorado Natural Heritage Inventory, Denver. Appendix D. 113 pp.

DAUBENMIRE, R. 1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. Ecol. Monogr. 22:301–330.

———. 1970. Steppe vegetation of Washington. Washington Agric. Expt. Sta. Tech. Bull. 62. 131 pp.

DONNELL, J. R. 1961. Oil-shale resources of the Piceance Creek Basin between the Colorado and White rivers, northwestern Colorado. Pages 835–890 *in* U.S. Geol. Surv. Bull. 1082-L.

FERCHAU, H. 1973. Vegetative inventory, analysis, and impact study of the Parachute Creek area, Garfield county, Colorado. Pages 1–77 *in* Colony environmental study, Thorne Ecological Institute, Boulder, Colorado. Part II, Vol. 1, Chap. VI.

———. 1974. An ecological analysis of the vegetation, Piceance Creek Basin, Rio Blanco and Garfield counties, Colorado. *In* Regional oil shale study. Report to the State of Colorado by Thorne Ecological Institute, Boulder. Vol. 14. 19 pp.

GALE RESEARCH COMPANY. 1980. Climates of the states: Colorado. Gale Res. Co., Book Tower, Detroit, Michigan. 2d ed. p. 104.

GRAHAM, E. H. 1937. Botanical studies in the Uinta Basin of Utah and Colorado. Ann. Carnegie Museum 26:1–432.

HANSON, W. R. 1939. The ecology of *Agropyron inerme* on protected and heavily grazed range land in Cache Valley, Utah. Unpublished thesis. Utah State Univ., Logan. 33 pp.

HANSON, W. R., AND L. A. STODDART. 1940. Effects of grazing upon bunch wheat grass. J. Amer. Soc. Agron. 32:278–289.

HULL, A. C., JR., AND M. K. HULL. 1974. Presettlement vegetation of Cache Valley, Utah and Idaho. J. Range Management 27:27–29.

ISAACSON, H. E. 1967. Ecological provinces within the pinyon-juniper type of the Great Basin and Colorado Plateau. Unpublished thesis. Utah State Univ., Logan.

JAMES, J. W., AND J. W. MARR. 1966. Route 40 mountain environmental transect: Colorado and Utah. Report prepared for the Institute of Arctic and Alpine Research, Univ. of Colorado, Boulder. 218 pp. + appendices.

KARTESZ, J. T., AND R. KARTESZ. 1980. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. Univ. of North Carolina Press, Chapel Hill. 498 pp.

KEAMMERER, W. R. 1974. Vegetation of Parachute Creek Valley. Pages 4–91 *in* Environmental inventory and impact analysis of a proposed utilities corridor in Parachute Creek Valley, Colorado. Unpublished report prepared for Colony Development Operation, Atlantic Richfield Co., Operator, Denver.

———. 1977. Final report: vegetation baseline studies, oil shale tract C-b. Unpublished report. Stoecker-Keammerer and Assoc., Ecological Consultants, Boulder, Colorado. 183 pp.

KEAMMERER, W. R., AND D. B. KEAMMERER. 1980. Preliminary vegetation studies on the Naval Oil Shale Reserve. Unpublished report prepared for TOSCO Corp., Denver, Colorado, by Stoecker-Keammerer and Assoc., Ecological Consultants, Boulder. 14 pp.

KEAMMERER, W. R., AND S. J. PETERSON. 1981. Vegetation studies on the Naval Oil Shale Reserve. Unpublished report prepared for TRW Energy Systems Group, McLean, Virginia, by Stoecker-Keammerer and Assoc., Ecological Consultants, Boulder, Colorado. 77 pp.

KEAMMERER, W. R., AND R. E. STOECKER. 1975. Vegetation and wildlife studies along proposed corridors for oil shale tract C-b. Unpublished report prepared for Shell Oil Co., Operator, Denver, Colorado, by Stoecker-Keammerer and Assoc., Ecological Consultants, Boulder, Colorado. 86 pp.

MARR, J. W., AND D. L. BUCKNER. 1974. Colorado to Wyoming pipeline corridor study. Unpublished

report prepared for Colony Development Operation, Atlantic Richfield Co., Denver, Colorado, by Thorne Ecological Institute, Boulder. 79 pp.

MARR, J. W., D. L. BUCKNER, AND C. MUTEL. 1973. Ecological analysis of potential oil products corridors in Colorado and Utah. Unpublished report prepared for Colony Development Operation, Atlantic Richfield Co., Denver, Colorado. 96 pp. + appendices.

MURRAY, D. K., AND J. D. HAUN. 1974. Introduction to the geology of the Piceance Creek Basin and vicinity, northwestern Colorado. Pages 29–39 *in* Guidebook to the Energy Resources of the Piceance Creek Basin, Colorado. Rocky Mountain Assoc. of Geologists, Denver, Colorado.

PASSEY, H. B., AND V. K. HUGIE. 1963. Variation in bluebunch wheatgrass in relation to environment and geographic location. Ecology 44:158–161.

PEET, R. K. 1981. Forest vegetation of the Colorado Front Range: composition and dynamics. Vegetatio 45:3–75.

PETERSON, J. S., AND W. L. BAKER. 1982. Inventory of the Piceance Basin, Colorado: threatened and endangered plants, plant associations, and the general flora. Unpublished report prepared for the Craig District Office, Bureau of Land Management, by Colorado Natural Heritage Inventory, Denver. 5 volumes.

PFISTER, R. D. 1982. Designing succession models to meet management needs. Pages 44–53 *in* J. E. Means, ed., Forest succession and stand development research in the northwest. Proceedings of the symposium held 26 March 1981 at Corvallis, Oregon. Forest Research Laboratory, Oregon State Univ., Corvallis.

SHUTE, D., AND N. E. WEST. No date. The application of ECOSYM vegetation classification to rangelands near Price, Utah. Unpublished reports 14 and 16. *In* J. A. Henderson and L. S. Davis, eds., Ecosystem classification and data storage system for natural resources management. Department of Forestry and Outdoor Recreation, Utah State Univ., Logan. 53 pp.

THORNE ECOLOGICAL INSTITUTE. 1973. Environmental setting of the Parachute Creek Valley: an ecological inventory. Pages 36–40, map *in* Unpublished report prepared for Colony Development Operation, Atlantic Richfield Co., Operator, Denver, Colorado, by Thorne Ecological Institute, Boulder.

TIEDEMAN, J. A. 1978. Phyto-edaphic classification of the Piceance Basin. Unpublished dissertation. Colorado State Univ., Fort Collins. 281 pp.

TIEDEMAN, J. A., AND C. TERWILLIGER, JR. 1978. Phyto-edaphic classification of the Piceance Basin. Colorado State Univ., Range Science Department Science Series 31. 265 pp.

TRIPP, W. P., L. W. WILLIAMS, D. K. ALSTATT, J. J. RAWINSKI, AND C. F. SPEARS. 1982. Soil survey of Rio Blanco county area, Colorado. U.S. Dept. of Agric., Soil Conservation Service, and U.S. Dept. of the Interior, Bureau of Land Management. 219 pp. + maps.

VORIES, K. C. 1974. A vegetation inventory and analysis of the Piceance Basin and adjacent drainages. Unpublished thesis. Western State College, Gunnison, Colorado. 243 pp.

WARD, R. T., W. SLAUSON, AND R. L. DIX. 1974. The natural vegetation in the landscape of the Colorado Oil Shale region. Pages 30–66 *in* C. W. Cook, ed., Surface rehabilitation of land disturbances resulting from oil shale development. Final Report, Phase I, to the Colorado Department of Natural Resources. Environmental Resources Center, Colorado State Univ., Fort Collins, Tech. Rep. Series 1.

WIGHT, J. R., AND H. G. FISSER. 1968. *Juniperus osteosperma* in northwestern Wyoming: their distribution and ecology. Univ. of Wyoming, Agric. Expt. Sta. Sci. Monogr. 7. 27 pp.